

## MAGNETIC LOCATION OF C IV EVENTS IN THE QUIET NETWORK

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## INTRODUCTION

As observations of the quiet Sun have improved in spatial and temporal resolution, it has become increasingly apparent that the "quiet" solar atmosphere is in fact quite dynamic. The existence of at least one class of solar activity occurring outside major active regions has been well-known for some time; the localized sites of intense heating called coronal bright points or X-ray bright points (XBP) were first seen in 1969 (Vaiana et al. 1970).

The XBP correspond to small magnetic bipoles (Krieger et al., 1971; Harvey et al., 1975a; Golub et al., 1977), but not all bipoles have associated XBP. Golub et al. find no obvious coronal heating signature for half of their designated bipoles. A less rigorous definition of the amount of flux required to constitute a bipole would have resulted in an even larger fraction of non-XBP bipoles. Yet we might expect that the heating by loop activations observed at XBP-associated bipoles (Sheeley and Golub, 1979) is present at these other bipoles as well: Golub et al. (1976b) find that bipoles having lower flux are associated with XBP having shorter lifetimes, and Golub et al. (1976a) find that the number of XBP with lifetimes in a given range increases toward shorter lifetimes, down to the 2h lower lifetime cutoff for XBP included in their study. These shorter-lived bipoles might not all yield coronal brightenings of sufficient magnitude or longevity to appear on the relatively infrequent (one per hour) X-ray photographs examined by Golub et al. (1977). However, such activity could manifest itself in the transition region, perhaps as the turbulent events and jets recently observed with HRTS (e.g. Brueckner and Bartoe, 1983). Another class of jet-like events, the H-alpha and EUV macrospicules, has been identified with flares at XBP (Moore et al., 1977), and impulsive heating at XBP is apparent in the transition region observations discussed by Habbal and Withbroe (1981).

This sort of activity should be observable with the Ultraviolet Spectrograph and Polarimeter (UVSP) on the Solar Maximum Mission (SMM). We have examined UVSP observations of C IV intensity in the quiet Sun and

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compared them to magnetograms and He I 10830 Å spectroheliograms from Kitt Peak National Observatory (KPNO). The He I data have been shown to be a useful proxy for high-resolution soft X-ray data for purposes of locating coronal bright points (Harvey et al., 1975b). We find evidence that impulsive heating processes are common at small bipoles, and many of these are bipoles other than those having associated XBP.

## THE OBSERVATIONS

The observations were made between 3 and 9 April 1985. Spatially rastered UVSP intensity measurements were obtained at 11 wavelength positions in the 1548 Å line of C IV. The wavelength positions were separated by 150 mÅ. Slit set 4 was used, combining a 3" x 3" entrance slit with a 300 mÅ exit slit. 120" x 120" rasters (40 x 40 pixels) were taken in a variety of quiet Sun regions including disk center, the equatorial limb, and the poles. Each raster took 2 m to complete, so successive rasters at the same position in the line were made 22 m apart. Two of the 11-position raster sets were typically obtained during a satellite orbit.

We see many fluctuations in C IV emission at sites throughout the network and in cell interiors, and so must set some arbitrary threshold for what we will call a "bright" point or event. The following criteria correspond fairly well to those intensity levels which are visually striking on linear gray-scaled images whose maxima are adjusted to yield dark cell interiors: for line center rasters, pixels which are at the  $5\sigma$  level; for the two rasters adjacent to line center,  $6\sigma$ ; for rasters farther in the wings,  $7\sigma$ .

Some sites are bright throughout the typical 44m observing period and in all parts of the C IV line. Other bright points appear and disappear fairly rapidly, sometimes being notable in only 1 or 2 successive rasters. These are usually seen in the wings of the line, rather than at line center. Confinement of a bright event to so few of these rasters may be the result of either limited observable wavelength range or short lifetime. That is, these may be fairly long-lived sites of jet-like flows, or they may be events of arbitrary line profile whose intensities are above our assigned threshold values for less than 4 m. Previous observations of many short-lived brightenings in active regions (Porter et al., 1984) argue for lifetimes less than 4 m for most of the events defined by these thresholds. The jets observed by HRTS also have short lifetimes, typically 80 s or less. Since long-lived bright jets therefore seem unlikely, we shall refer to events occurring in only 1 or 2 of our C IV rasters as short-lived.

We superposed the C IV rasters on the magnetograms and He I spectroheliograms to within about 6" using solar coordinates derived from the Fine Pointing Sun Sensor onboard SMM. Within that limited range, we varied the colocation in order to find the best correspondence of C IV network to solar magnetic network or He I dark regions over the entire field of view.

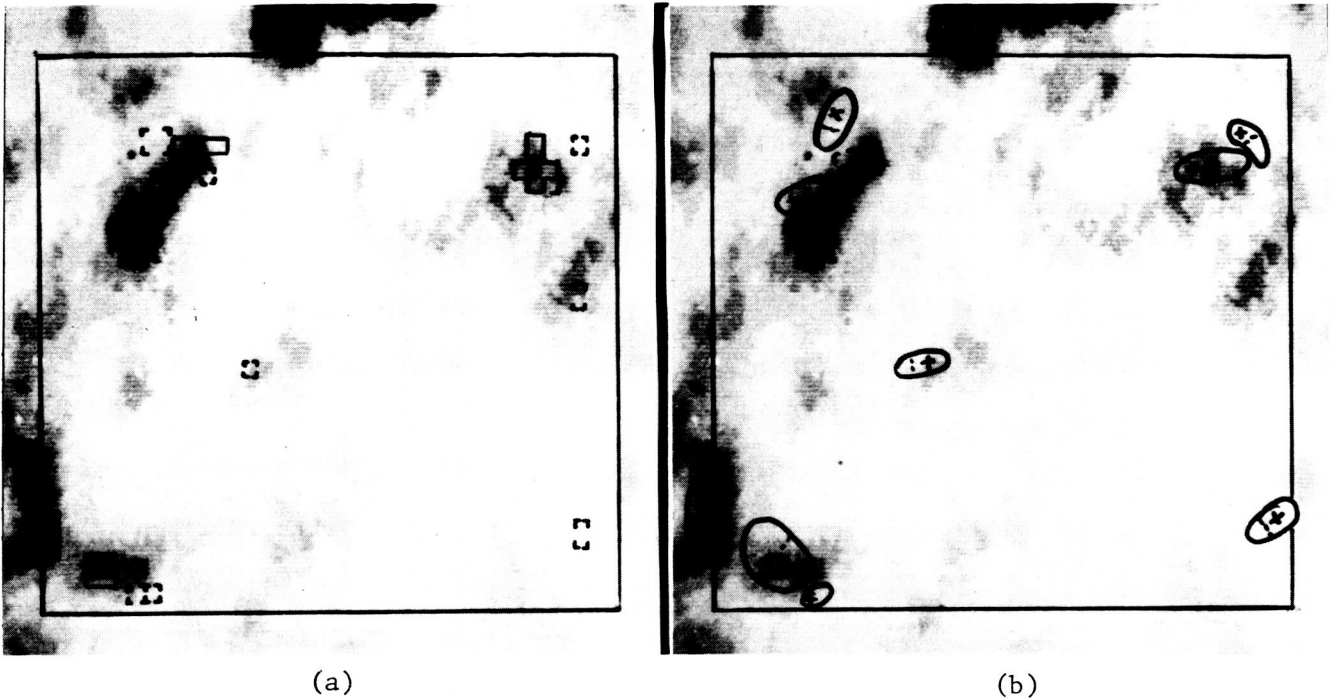


Figure 1. (a) A He I 10830 Å spectroheliogram taken 1 h after UVSP observations in the 1548 Å line of C IV. Long-lived C IV bright pixels are indicated by complete squares; transient events by corners. The long-lived sites are in the darkest He I areas, corresponding to XBP. Most sites of transient events are apparently heated too sporadically to display a He I (or coronal) signature. (b) Areas of magnetic bipoles underlying the C IV sites are superimposed on the He I spectroheliogram. All but one of the C IV sites overly bipoles. Note the correlation of bipole area with C IV brightness duration and He I darkness.

Figure 1a shows a KPNO He I 10830 Å spectroheliogram, obtained one hour after completion of two full scans through the C IV line by the UVSP on 7 April 1985. Complete squares indicate the locations of four long-lived bright C IV sites. Persistence of heating at these sites is well above our "longevity" criterion (intensities above threshold in 3 out of the 22 rasters comprising the double line scans), since even the weakest of them qualifies as "bright" in 5 rasters. Relative intensities do vary considerably in time at these sites, in some cases falling below threshold and then rising again, so the qualifying rasters are not necessarily consecutive. The variations may be multiple events in a single loop or the sequential activation of multiple loops within any given 3" x 3" pixel. Pixels which are the sites of short-lived events are denoted by corners alone. The spatial associations here are representative of those for all the C IV raster sets we have examined. All four of the long-lived C IV bright points are in very dark He I areas. These dark He I kernels almost certainly represent XBP (Harvey et al., 1975b). By contrast, locations of the short-lived C IV brightenings are generally unremarkable in He I, with most showing no darkening at all. The site near raster

center and the one below and to the left of the upper left long-lived site are exceptions, showing some moderate darkening.

The best fit of the C IV raster to the magnetogram places the brightest C IV features over the neutral lines of small magnetic bipoles. We find that the long-lived C IV sites correspond to the stronger bipoles (i.e., bipoles having more area and flux). The short-lived C IV bright points also overly bipoles, though the flux and area of these is much less than for the long-lived sites. The areas covered by the bipoles associated with all of these sites are drawn on the helium spectroheliogram in Figure 1b. The correlation of bipole area with C IV brightness duration and He I darkness is easily seen. The magnetic field underlying the long-lived site at the upper left is not a simple bipole; the positive patch enclosed within the dashed neutral line is surrounded by many small concentrations of negative field. Some of these are apparently halves of small bipoles in their own right--two of these associated with short-lived events are shown.

Only those bipoles associated with C IV bright sites are drawn here; there are others present on the magnetogram, so we cannot say whether all bipoles are sites of events such as these. In particular, there is one strong bipole about 15" - 20" below the long-lived site at the upper left area which we might also have expected to have an associated long-lived C IV bright point, but the C IV intensity at the site never rises above our threshold values. It does correspond to moderately bright network which exhibits several lesser brightenings (most notable in rasters near line center in both scans), and to a dark He I area. There may have been greater C IV events here (as well as at lesser bipoles) which escaped detection because of the sparse temporal sampling of the data.

For one short-lived site, the one at center right, we are unable to discern an underlying neutral line. This site lies on the edge of a positive unipolar patch, however, so it is possible that a small, unresolved region of negative polarity is present here.

## DISCUSSION

We find strong fluctuations in C IV intensity at sites of magnetic bipoles throughout the network. The longer-lived C IV bright points overly the largest bipoles and correspond to He I dark points and thus presumably XBP; the shorter-lived sites are associated with bipoles lying near the limit of the magnetogram's sensitivity and usually have no long-lived coronal signature. Many smaller short-lived brightenings, perhaps associated with bipoles too small to detect, occur throughout the network. Time histories of intensity at the various sites shows that the heating is quite unsteady even at the long-lived sites; the impression is that some portion of the strong C IV emission at these sites is maintained by a series of small flare-like events similar to those which occur less frequently at the short-lived sites. This is in agreement with the interpretation of NRL EUV spectroheliograms by Sheeley and Golub (1979), who find that an XBP consists of a collection of small loops which

sequentially and independently brighten. Thus we conclude that the stochastic process whereby convective shuffling of loop footpoints leads to many topologically dissipative events in active regions and the larger bipoles treated here (see Porter et al., 1984 and references therein) continues to operate in regions of fewer, weaker flux loops, but the resulting events above threshold are less frequent.

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